Interference Mitigation in Downlink Co-tier Network using Dynamic Power Control

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Abstract- **Recently femtocellsis seem to bethe most promising solution to the indoor wireless internet users. However, the extend number of user has led to increase the capacity demand for packet-based mobile broadband system. Due to the scarcity of the spectrum resources, has contributed femtocells to share spectrum with other networks, which inevitably bring in severe interference. Therefore, this paper is proposing a dynamic power control in order to mitigate the interference level in thedownlink co-tier networks, hence the good QoScan be served.**

Keywords:*Femtocells, Interference mitigation, dynamic power control*

I. Introduction

Over the next few years, it is believe that billions of devices will be connected to the internet based applications using 3G (3rd Generation) and LTE (Long Term Evolution) mobile wireless networks. It was predicted that the traffic growth of up to 30 times was taking place from 2010 to 2015[2]. Hence, by 2016 more than 10 exabytes of traffic per month will be circulating across cellular networks and more than 4 billion Third Generation Partnership Project (3GPP) wireless subscriptions will be operating in the network[3]. With the extend number of the user certainly will create tremendous demand for mobile wireless capacity and ubiquitous coverage.Theuser, who adapted the LTE speeds, definitely will expect the same speed whether they are outdoors or in-building.So, the important of the excellent Quality of Service (QoS) is crucial in LTE regardless where the user stand.

In LTE architectures, the QoS management is controlled by the base station called eNodeB or eNb[1] for macrocell networks. The eNb is where the resource is performed. The problem with eNb is, it works depends on the geographical position. The user might experience bad performance when they are in a poor coverage area like home or in building but might experience a very good QoS if located close to the base station. Furthermore, study by Allied Business Intelligence (ABI) research, shows that in the future demand for the cellular services is more than 50% of voice calls and more than 70% of data traffic is expected to originate from indoors [12]. Hence, the born of femtocells have been introduced as a solution for a better coverage for small areas like office and home.Femtocells in LTE is called Home EnodeB(HeNb). It is a wireless access point that improves cellular reception in an indoor environment.

Two access method is classify in LTE networks which is open-access and closed-access femtocells. The closed-access femtocell is believed causes the most harmful interference. The main interference in femtocells is usually focused on macro-to-femto and femto-to-femto interference. The macro-to-femto interference generally occur in handover process between macrocell and femtocells.Whilethe uncoordinated ad hoc deployment of femtocellshas contributed to the femto-to-femtointerference issues.In a small area, strong cell edge interference might be experienced if a user use a high date rate service in a room whereas the other femtocell is installed on the other side of the wall. Usually high transmission power is involved in order to have a good QoS. However, if this transmission power is set too high will cause interference among femtocell, nonetheless if it is set too low it will decrease the bitrate. So it is important that transmission power is set at the maximum level without decreasing the bitrate.

II. Related Works

There have been substantial researchesfocusing on the interference mitigation through power control [11] [19] [25]. The power control mechanism is actually the method use in order to set the transmission power. The mechanism is suitable to use in both co-tier interference and cross-tier interference levels. The focus of this mechanism generally is reducing the transmission power of the HeNbs where the high interference could be avoided. With a good interference management, one of the advantages of this mechanism is, both eNbs and HeNbs can enjoy using the entire bandwidth in the networks.

High transmission power in fact is good in term of getting the desirable results because in a low femtocell density scenario there will be no interference from neighbours even with this high transmit power . So it may perform a good coverage to the area as well. However, if this high transmit power is apply at the high femtocell density area, the area will be jammed with the users which was more close to the base station. In addition, the macro users have the priority to the resources that are not being use around them compare to the femtocellsusers[16]. In a different situation if the femtocell located far from the base station and requested to raise its power level, it might transmit the power with high interference level to the neighbouring femtocells. In this situation, the femtocells neighbours could end up in a dead zones.Because of the decreasing power control proven to decrease the interference level, it can be consider as a solution to mitigate interference. However, there are several issues to take into account. Firstly, ever since the minimization of transmission power could lead to low the interference level, it is important to take notes that the quality of services might be degraded due to the power reduction. This means that the bitrate transmission could be reduced too. The Modulation and Coding Scheme (MCS) and the Transport Block Size(TBS) are computed based on the SINR value, therefore even the power transmit is minimized to control the interference level, the bitrate transmission should be maintain. Most previous works that studies power control mechanism usually measure their performance using SINR [11][26].

One of the best power control mechanism is proposed by [11] where they introduced a self-power control in order to mitigate interference. The idea is to let the femtocell to measure the distance between the user and the femtocell itself and then self-calculate a suitable transmission power level to transmit. In this work, they channelled the models using an indoor propagation model defined in [24] for a dense urban deployment of femtocells. They used the recommended pathloss model, considering only the distance, R between the transmitter and the receiver where R expressed in meters.

$$PL\,[dB] = 127 + 30\,[\log 10\,(R/1000)]$$

Then, based on the result, they can calculated the SINR value, the MCS and TBS before send to the base station.

In [25] the authors are proposing a power allocation algorithm in order to maximize the radio resource utilization. In the works of Daolong Sun and team, they study the interference level in the downlink system from femtocells base stations to the macrocell users. Based on the information exchange between femtocell and macrocells, the cognitive radio in the femtocells will avoid allocating channels that have been occupied by the macrocells. They will operate on the orthogonal channel so cross-tier interference can be avoided. For the power control in the cognitive femtocell network, they form a Lagrangian function in order to solve the power allocation problem.

In [27], the works of Sudarshan et al introducing their method of controlling power transmission by using a game theory approach. The main idea is to maximized the throughput gain of each femtocells in the network using the power limitation. They used the non-cooperative games where femtocells is set as the players. Macro users play as the lead player in the game, while the femtocell plays as the followers. They need to play a sub-game in a non-cooperative manner aims for the Nash equilibrium. However, the results show that the proposed algorithm is suboptimal.

III. Proposed Interference Mitigation Method

In this study, all the process is carried on by performing the steps describe in proposed algorithm.But firstly, for an easy understanding, femtocells network are describe as follows:

- Femtocells F= {f1, f2,f3 ....}
- Users per femtocell U= {u1,u2,u3 ....}
- Sub-bands S= {s1,s2,s3 ...}

The focus of this work is about the power transmission control based on the SINR value calculated. So, to calculate the path loss, considering the 3GPP pathloss*pl* between a user and a femtocell*f* represented by [12] is

$$Pl_{u,f} = 127 + (30 * \log(d)) \quad (1)$$

Where d is a distance between a user *u* and the femtocell base station.Then, to perform a total bandwidth distribution among all users, it is necessary to dividethe total bandwidth into sub-bands. Also the total transmission power *TxP* must be divided by the number of sub-bands in order to get the sub-band transmission power$\delta_{u,f}$

$$\delta_{u,} = 10\log_{10}\left(\frac{10^{\frac{TxP-30}{10}}}{nsb}\right) \quad (2)$$

Where nsb = |S| represents the number of sub-bands. Using (Equation 1) and (Equation 2) the interference for user γ_u for user u is computed as follows:

$$\gamma_u = \sum_{f1}^{fn} (\delta - pl_{u,f}) \quad (3)$$

In order to obtain the noise-plus-interference we first compute the noise in db asfollows:

$$noise_{db} = nf + np + 10\log_{10}(schb) - 30 = -148.95 \quad (4)$$

Where nf = 2.5dbm is the noise figure, np = −174dbm is the noise power, and schb =180kHz is the subchannelbandwidth.In order to compute the measured SINR value *mSinr*.

$$mSinr = \delta - 10\log_{10}(10^{\lambda} + \gamma) \quad (5)$$

Where $\lambda = \frac{noise}{10}$; noise is in db

Hence,

$$SINR = \frac{\sum_{s1}^{sl} mSinr}{nsb}$$

From the calculation of SINR , we can calculate the Modulation and Coding Scheme (MCS) value as shown in Table 1 and therefore Transport Block Size (TBS) can be computed following the 3GPP specification. This MCS value calculated will constantly reported to the base station. A throughput value will be computed at the HeNb using the received TBS in the last period.

LTE MSC (Modulation and Coding Schemes)

MCS	Modulation	Code Rate	SINR [db]
MCS1	QPSK	1/12	-4.63
MCS2	QPSK	1/9	-2.6
MCS3	QPSK	1/6	-0.12
MCS4	QPSK	1/3	2.26
MCS5	QPSK	1/2	4.73
MCS6	QPSK	3/5	7.53
MCS7	16QAM	1/3	8.67
MCS8	16QAM	1/2	11.32
MCS9	16QAM	3/5	14.24
MCS10	64QAM	1/2	15.21
MCS11	64QAM	1/2	18.63
MCS12	64QAM	3/5	21.32
MCS13	64QAM	3/4	23.47
MCS14	64QAM	5/6	28.49
MCS15	64QAM	11/12	34.6

Table 1: Modulation and Coding Schemes

Next, the most important method in this study is a bargaining game between two players which are*SINR*and *Throughput*that are competing for the optimal transmission power value. This bargaining game has been introduced in previous paper [11] by Mauricio and his team. In the game, *SINR* will propose to set the transmission power as low as possible, while *Throughput* will propose to set the power as high as possible in order to increase its level. The aim is to find an optimum trade-off between them in order to avoid the femtocells to transmit extra power than the userneed.An algorithm is proposed based on the theory.

Algorithm Proposed Algorithm

1. Set the HeNb min transmission power
2. Set the HeNb max transmission power
3. Compute_Pathloss(); {According Eq (1)}
4. Compute_SINR(); {According Eq (2)}
5. Compute_MSC();
6. Compute_TBS();
{Start Bargaining}
player 1<-- SINR
player 2<--Throughput{ Computed at the HeNb using the received TBS in the last period}
7. tx-powcom <-- perfom_BargainGame(player1,player2);
if tx-powcom < tx_power then
  tx_power <-- tx_power - 1
else
  tx_power <-- tx_power + 1
end if

To perform the resource allocation model, thefemtocell scenariois set as follows. A single cell with several femtocells are used and distributed in abuilding. The number of femtocells which are neighbours relatively close to each other start from1 until 10, increasing in one unit in order to increase the interference level. For theproposed scheme, there is only one user at each femtocell which utilizes all thefemtocell resource blocks. Only one scenario where all femtocells serve video flows is tested ,while another one using VoIP flows. The 3GPP 5x5 standard for femtocell is usedto model the indoor scenario [11]. LTE-Sim simulator is used in this works to run the simulation. This work is focused only on femto-to-femtointerference mitigation therefore macrocell interference is not taken into account.Users are constantly moving at speed of 1 kmph in random walking mobility model. The simulation parameters are described in the Table 2.

Parameters	Values
Simulation duration	60s
Frame structure	FDD
Apartement size	100m/-2
Bandwidth	10MHz
Slot duration	0.5s
Scheduling time (TTI)	1ms
Scheduler	EXP-RULE
Number of RBs	50
Max delay	0.1s
video bit-rate	242kbps
Number of femtocells	1, 2, 3, ..., 8or10
Users per femtocell (1st. Approach)	1
Pathloss	PL = 127+30log(d)
Multipath	Ped-A
PenetrationLoss	0 dB
Shadowing	log-normal distribution (mean = 0dB, standard deviation = 8dB)

Table 2: Simulation Parameters

IV. Analysis and Simulation Results

The efficiency of the algorithm is presenting in the simulation results. Figures show two generated curves. The red curve represent the fixed transmission data which label as 23dbm. While the blue curve represent the Dynamic Power Control(DPC) algorithm data. From figure 1 shows the Throughput in kbps versus number of femtocells in horizontal axis. In figure 1 clearly shows that the average of Throughput data on the fixed transmission power decrease abruptly even at the second added femtocell where the interference also slightly add up. On the other hand, DPCdata still maintain.

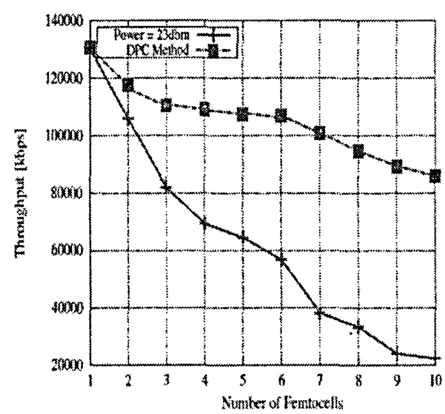

Figure 1: Throughput in video flow

In figure 2 represents the interference level by SINR values against the total throughput gain for video flows. The result of the simulation had shown that the

SINR decreases in the blue curves. This means interference decreases using this method as compared to the fixed transmission power.

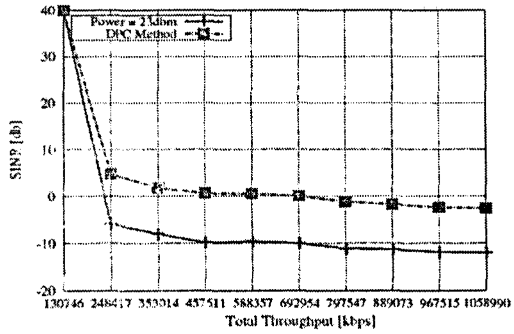

Figure 2: Interference in video flow

V. Conclusion and Future Works

This paper is mainlyfocusing on mitigating interference in the downlink co-tier network by using thetransmission power control as the dynamic variable.From the simulation results, we can see that the throughput is increasing while the interference is decreasing which means that by implementing the dynamic power control, higher possibility we can achieve the desirable quality of services. So, in conclusion, we can say that power transmission level plays a big role in contributing to a good QoS. By applying the method it is proven by numerical result that it can mitigate interference towards achieving the good QoS. Nevertheless, it is important to highlight that it is necessary to take into account the QoS whenever dealing with interference mitigation in real time because after all, a good coverage is all what we as a user always desire.

Since in this studies itsonly focusing on femto to femto interference however in the real networks, a scenario with macrocell interference also happens and mostly from the handover process between macrocells and femtocells. It is believe that the closed-access system that contribute the most destructive interference in the macro to femto scenario. The femtocell access point will cause interference to the macrocell user equipment nearby therefore the simulation process should consider a cross-tier interference. It is because of the interference is caused by the network elements in a different network layer. So, in order to implement the whole interference mitigation to success in real networks, it is best to consider macrocell into account in the future works.

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